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STUDY OF ECONOMY OF GREEN BUILDING

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ABSTRACT

This project work deals with understanding the necessity of green building, its features, and concepts behind the same. It also deals with study economic benefit of green building. It also elaborates about various requirements of building to be green and weightage for various aspects etc and is only restricted to the small building of ground plus one floor.

KEYWORDS: Green Building

INTRODUCTION

Objectives of the Project

- To promote the green architecture and create awareness about the environmental protection in the society.
- To do a detailed study of green materials.
- To highlight the green building materials selection criteria.
- To highlight the economic benefits of the green building.

LITERATURE SURVEY

What is “Green”?

Green is not just a colour! It is much more than the colour. Green symbolizes environment friendly practices in all facets of human endeavour. “Green” is the voluntary pursuit of any activity, which encompasses concern for energy efficiency, environment, water conservation, use of recycled products and renewable energy. Incorporating excellent practices that result in environment protection, water conversation, energy efficiency, usage of recycled products and renewable energy, is termed as going green.

What is a Green Building?

Green building increases the efficiency of buildings by harvesting energy, water, and materials. It also reduces building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and also throughout the complete building life cycle.

Green building is also sometimes known as "sustainable building" or "environmental building". The practice can lead to benefits including reduced operating costs by using less energy and water, improved public and occupant health due to improved indoor air quality, and reduced environmental impacts by lessening storm water runoff and the heat island effect.

Green building is an essential component of the related concepts of sustainable design, sustainable development and sustainability. As a component of sustainability, a common goal of green building is achieving aesthetic harmony between a structure and its surrounding environment.

A Green Building is one that is environmentally responsible, profitable and a healthy place to live and work. Green Buildings ensure that waste is minimized at every stage during the construction and operation of the building, resulting in low cost.

The appearance of Green Building will be similar to any other building. However, the difference is in the approach, which revolves around a concern for extending the life span of natural resources; provide human comfort, safety and productivity.

Features of Green Building

The parameters to define a green building are sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor air quality, etc. The requirements of the green building are satisfied with the following features which are described in detail below

Sustainable Sites

- **Measures to prevent erosion of soil:** Prevent soil erosion before, during, and after construction by controlling storm water runoff and wind erosion. Consider silt fencing, sediment traps, construction phasing, stabilization of slopes, and maintaining and enhancing vegetation and groundcover.
- **Minimal disturbance to landscape and site conditions:** Protect hillsides using adequate erosion control measures such as erosion control blankets and/or sedimentation ponds to collect runoff.
- **Rainwater harvesting:** Select a site and develop design strategies that will require minimum alterations and ecological impacts to the watershed. Use biologically based storm water management features such as sediment control ponds, pools, wetlands along drainage courses, and infiltration basins to retain and treat storm water on site and/or in adjacent areas. Retain and/or maximize pervious and vegetated areas of the site.
- **Landscapes to reduce heat island effects:** Locate trees and shrubs to support passive heating and to complement cooling in outdoor spaces and buildings and to create seasonally appropriate natural ventilation corridors. Locate site elements to maximize heating and cooling benefits, to ensure proper drainage, and to make pedestrian/vehicular movements safe and coherent. Design the overall site to reduce “heat island” effects. Exploit shading opportunities, and explore the possible use of high-albedo materials. Consider pervious surfaces for parking, walkways, plazas, etc. Use permeable paving for roads with infrequent use (e.g. fire roads). Design site lighting to eliminate light treespass from the building and site.

Water Efficiency

- **25% - 30% reduction in Usage of Potable Water:** Dual-Flush Toilets are Australian innovated fixtures that have two buttons that release different amounts of water for either liquid or solid waste.
- **Efficient use of Water and 100% Recycling of Waste Water:** Waterless urinals are urinals designed with a non-stick coating that eliminates the need to flush after use. These urinals use no water and therefore result in a 100% savings in water. Within a few years, these fixtures pay back their initial cost in water savings. There are no moving parts in these fixtures, therefore, they breakdown much less often. Also, since these urinals do not need to be flushed, there are no handles that can potentially transmit bacteria between users.

- **Water Efficient Landscaping:** Capture rainwater from impervious areas of the building for groundwater recharge or reuse. A rainwater collection system if installed would reduce water use and utility bills. There are also many environmental benefits such as less stress or load on municipal storm sewers and less demand on freshwater resources.

Energy and Atmosphere

- **Use of World Class Energy Efficiency Practices:** Design the electric lighting systems and components to minimize electric lighting energy use while still meeting project requirements and high visual quality. Use high efficiency lamps and luminaries with electronic ballasts. Use controls to reduce energy use (e.g., dimmers, occupancy sensors, and time clocks). Use low levels of ambient light with task lighting where appropriate. Direct/indirect lighting fixtures illuminate ceilings and walls, producing low-level ambient light that minimizes glare in computer rooms, Roof garden covering over 60% of roof area, water saving flow fixtures.
- **30% Reduction in Energy Over Normal Buildings:** Size openings, select glazing, and utilize shading devices (interior or exterior) to optimize day lighting and glare control while minimizing unwanted heat loss and heat gain. Optimize insulation to reduce heating and cooling energy consumption by heat losses and gains through the building envelope. Ensure the integrity of the building envelope to provide thermal comfort and prevent condensation. Use best air/vapor barrier practices.
- **Use of On-Site Renewable Energy:** Evaluate possibilities for the use of renewable energy (such as solar water heaters, geothermal heating and cooling systems, and solar walls). Evaluate feasibility of geothermal systems.

Materials and Resources

- **Use of Non-Toxic Recycled / Recyclable And Environmental Friendly Building Materials:** Fly ash cement, fly ash blocks, recycled aluminum, recycled steel, recycled tiles, low VOC paints, bamboo based products, HFC based high efficiency chillers, building controls, green roof, recycled wood.
- **Storage and Collection of Recyclables:** Collection, storage and disposal of building waste like paper and plastics, recycling of construction waste material like shuttering timber, paint cans, cement bags, etc, use of resources from sites like structural steel (angle plate and hollow sections), doors, broken china mosaic pieces for flooring, GI pipe sleeves, use of fly ash based cement and aerocon blocks.

Indoor Air Quality

- **Effective System Controls and Building Management Systems to maintain IAQ:** Installation of carbon dioxide sensors to monitor indoor air quality, 2-week building flush out before occupancy and replacement of AHU filters, use of composite wood.
- **Quality of Indoor Air Quality for Human Safety and Comfort:** Declaration of entire building as "Non-Smoking" area, operable windows and lighting controls in perimeter occupied areas, daylights and views for 90% of regularly occupied areas.
- **Use of low VOC Content Material:** Paints & Coatings, Adhesives & Sealants, Carpets.

Natural Ventilation and Cooling

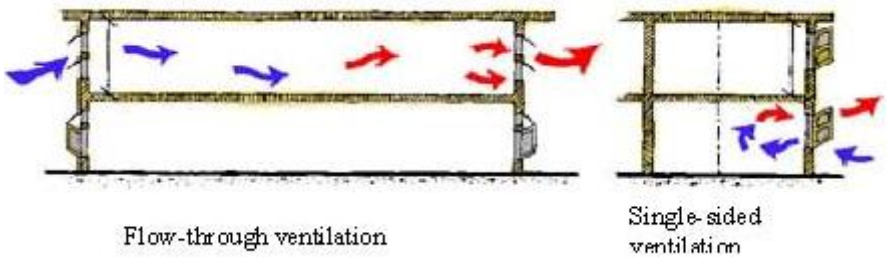

Figure 1: Natural Ventilation and Cooling

Natural, or passive, ventilation and cooling uses wind and the buoyancy of warm air to provide comfortable conditions within buildings during hot periods. When carefully combined with day lighting and thermal mass, natural ventilation can greatly reduce the cooling load in buildings, and minimize or eliminate the need for mechanical cooling in most circumstances.

Outdoor Air Requirement for Ventilation

Table 1: Outdoor Air Requirement for Ventilation

Application	Estimated Maximum Occupancy Persons/1000 sqft	Outdoor Air Requirements cfm/Person
Dining Room	70	20
Cafeteria	100	20
Kitchens	20	15
Office spaces	7	20
Reception	60	15
Conference	50	20
Smoking lounge	70	60
Auditorium	150	15

Principles of Sustainable Design

Design practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants in five broad areas are:

- Sustainable site planning.
- Safeguarding water and water efficiency.
- Energy efficiency and renewable energy.
- Conservation of materials and resources.
- Indoor environmental quality.

Principles of Green Construction

- **Minimize Resource Consumption:**
  - Energy

- Water
- Materials

- Maximize the re-usage of resources.
- Use renewable or recyclable resources.
- Protect the natural environment.
- Create a healthy, non-toxic human environment.
- Apply Life Cycle Cost Analysis.
- Pursue Quality in creating the built environment.

Greening Movement in Construction

New Urbanism and Sustainable Architecture are rapidly increasing. Green materials are becoming more prevalent and the focus on energy efficiency is increasing, developing healthy interior environments is critical. And increasing water efficiency is a growing concern.

What Are the Elements of Green Buildings?

- **Siting:** Start by selecting a site well suited to take advantage of mass transit. Protect and retain existing landscaping and natural features. Select plants that have low water and pesticide needs, and generate minimum plant trimmings. Use compost and mulches. This will save water and time. Recycled content paving materials, furnishings, and mulches help close the recycling loop.
- **Energy Efficiency:** Most buildings can reach energy efficiency levels far beyond California Title 24 standards, yet most only strive to meet the standard. It is reasonable to strive for 40 percent less energy than Title 24 standards. The following strategies contribute to this goal.
  - Passive design strategies can dramatically affect building energy performance. These measures include building shape and orientation, passive solar design, and the use of natural lighting.
  - Develop strategies to provide natural lighting. Studies have shown that it has a positive impact on productivity and well being.
  - Install high-efficiency lighting systems with advanced lighting controls. Include motion sensors tied to dimmable lighting controls. Task lighting reduces general overhead light levels.
  - Use a properly sized and energy-efficient heat/cooling system in conjunction with a thermally efficient building shell. Maximize light colors for roofing and wall finish materials; install high R-value wall and ceiling insulation; and use minimal glass on east and west exposures.
  - Minimize the electric loads from lighting, equipment, and appliances.
  - Consider alternative energy sources such as photovoltaics and fuel cells that are now available in new products and applications. Renewable energy sources provide a great symbol of emerging technologies for the future.

- Computer modeling is an extremely useful tool in optimizing design of electrical and mechanical systems and the building shell.

Materials Efficiency

- Select sustainable construction materials and products by evaluating several characteristics such as reused and recycled content, zero or low off gassing of harmful air emissions, zero or low toxicity, sustainably harvested materials, high recyclability, durability, longevity, and local production. Such products promote resource conservation and efficiency. Using recycled-content products also helps develop markets for recycled materials that are being diverted from California's landfills, as mandated by the Integrated Waste Management Act.
- Use dimensional planning and other material efficiency strategies. These strategies reduce the amount of building materials needed and cut construction costs. For example, design rooms on 4-foot multiples to conform to standard-sized wallboard and plywood sheets.
- Reuse and recycle construction and demolition materials. For example, using inert demolition materials as a base course for a parking lot keeps materials out of landfills and costs less.
- Require plans for managing materials through deconstruction, demolition, and construction.
- Design with adequate space to facilitate recycling collection and to incorporate a solid waste management program that prevents waste generation.

Water Efficiency

- Design for dual plumbing to use recycled water for toilet flushing or a gray water system that recovers rainwater or other nonpotable water for site irrigation.
- Minimize wastewater by using ultra low-flush toilets, low-flow shower heads, and other water conserving fixtures.
- Use recirculation systems for centralized hot water distribution.
- Install point-of-use hot water heating systems for more distant locations.
- Use a water budget approach that schedules irrigation using the California Irrigation Management Information System data for landscaping.
- Meter the landscape separately from buildings. Use micro-irrigation (which excludes sprinklers and high-pressure sprayers) to supply water in nonturf areas.
- Use state-of-the-art irrigation controllers and self-closing nozzles on hoses.

GREEN BUILDING MATERIALS

Introduction

The concept of sustainable building incorporates and integrates a variety of strategies during the design, construction and operation of building projects. The use of green building materials and products represents one important strategy in the design of a building.

Green Building Materials Offer Specific Benefits to the Building Owner and Building Occupants

- Reduced maintenance/replacement costs over the life of the building.
- Energy conservation.
- Improved occupant health and productivity.
- Lower costs associated with changing space configurations.
- Greater design flexibility.

Building and construction activities worldwide consume 3 billion tons of raw materials each year or 40 percent of total global use (Roodman and Lenssen, 1995). Using green building materials and products promotes conservation of dwindling nonrenewable resources internationally. In addition, integrating green building materials into building projects can help reduce the environmental impacts associated with the extraction, transport, processing, fabrication, installation, reuse, recycling, and disposal of these building industry source materials.

What is a Green Building Material?

Green building materials are composed of renewable, rather than nonrenewable resources. Green materials are environmentally responsible because impacts are considered over the life of the product (Spiegel and Meadows, 1999).

Green Building Material/Product Selection Criteria

Following are the material/product selection criteria:

- Resource efficiency.
- Indoor air quality.
- Energy efficiency.
- Water conservation.
- Affordability.

Resource Efficiency

Resource Efficiency can be accomplished by utilizing materials that meet the following criteria:

- **Recycled Content**: Products with identifiable recycled content, including postindustrial content with a preference for post consumer content.
- **Natural, Plentiful or Renewable**: Materials harvested from sustainably managed sources and preferably have an independent certification (e.g., certified wood) and are certified by an independent third party.
- **Resource Efficient Manufacturing Process**: Products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste (recycled, recyclable and or source reduced product packaging), and reducing greenhouse gases.
- **Locally Available**: Building materials, components, and systems found locally or regionally saving energy and

resources in transportation to the project site.

- **Salvaged, Refurbished, or Remanufactured**: Includes saving a material from disposal and renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product.
- **Reusable or Recyclable**: Select materials that can be easily dismantled and reused or recycled at the end of their useful life.
- **Recycled or Recyclable Product Packaging**: Products enclosed in recycled content or recyclable packaging.
- **Durable**: Materials that are longer lasting or are comparable to conventional products with long life expectancies.

Indoor Air Quality

Indoor Air Quality (IAQ) is enhanced by utilizing materials that meet the following criteria:

- **Low or Non-Toxic**: Materials that emit few or no carcinogens, reproductive toxicants, or irritants as demonstrated by the manufacturer through appropriate testing.
- **Minimal Chemical Emissions**: Products that have minimal emissions of Volatile Organic Compounds (VOCs). Products that also maximize resource and energy efficiency while reducing chemical emissions.
- **Low-VOC Assembly**: Materials installed with minimal VOC-producing compounds, or no-VOC mechanical attachment methods and minimal hazards.
- **Moisture Resistant**: Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.
- **Healthfully Maintained**: Materials, components, and systems that require only simple, non-toxic, or low-VOC methods of cleaning.
- **Systems or Equipment:** Products that promote healthy IAQ by identifying indoor air pollutants or enhancing the air quality.

Energy Efficiency

Energy Efficiency can be maximized by utilizing materials and systems that meet the following criteria:

- Materials, components, and systems that help reduce energy consumption in buildings and facilities.
- Use a properly sized and energy-efficient heat/cooling system in conjunction with a thermally efficient building shell. Maximize light colors for roofing and wall finish materials; install high R-value wall and ceiling insulation; and use minimal glass on east and west exposures.

Water Conservation

Water Conservation can be obtained by utilizing materials and systems that meet the following criteria:

- Products and systems that help reduce water consumption in buildings.
- Design for dual plumbing to use recycled water for landscaped areas or other nonpotable water for site irrigation.

Affordability

Affordability can be considered when building product life-cycle costs are comparable to conventional materials or as a whole, are within a project-defined percentage of the overall budget.

Three Basic Steps of Product Selection

Product selection can begin after the establishment of project-specific environmental goals. The environmental assessment process for building products involves three basic steps.

- Research
- Evaluation
- Selection

Research

This step involves gathering all technical information to be evaluated, including manufacturers' information such as Material Safety Data Sheets (MSDS), Indoor Air Quality (IAQ) test data, product warranties, source material characteristics, recycled content data, environmental statements, and durability information. In addition, this step may involve researching other environmental issues, building codes, government regulations, building industry articles, model green building product specifications, and other sources of product data. Research helps identify the full range of the project's building material options.

Evaluation

This step involves confirmation of the technical information, as well as filling in information gaps. For example, the evaluator may request product certifications from manufacturers to help sort out possible exaggerated environmental product claims. Evaluation and assessment is relatively simple when comparing similar types of building materials using the environmental criteria. For example, a recycled content assessment between various manufacturers of medium density fiberboard is a relatively straightforward "apples to apples" comparison. However, the evaluation process is more complex when comparing different products with the same function. Then it may become necessary to process both descriptive and quantitative forms of data. A life cycle assessment (LCA) is an evaluation of the relative "greenness" of building materials and products. LCA addresses the impacts of a product through all of its life stages. Although rather simple in principle, this approach has been difficult and expensive in actual practice (although that appears to be changing). One tool that uses the LCA methodology is BEES (**B**uilding for **E**nvironmental and **E**conomic **S**ustainability) software. It allows users to balance the environmental and economic performance of building products. The software was developed by the National Institute of Standards and Technology's Building and Fire Research Laboratory.

Selection

This step often involves the use of an evaluation matrix for scoring the project-specific environmental criteria. The total score of each product evaluation will indicate the product with the highest environmental attributes. Individual criteria included in the rating system can be weighted to accommodate project-specific goals and objectives.

ECONOMIC OF GREEN BUILDINGS

What is Green Economics?

Green economics is the economics of the real world—the world of work, human needs, the Earth's materials, and how they mesh together most harmoniously. It is primarily about "use-value", not "exchange-value" or money. It is about quality, not quantity for the sake of it. It is about regeneration---of individuals, communities and ecosystems-not about accumulation, of either money or material.

What Makes a Building Green?

A green building, also known as a sustainable building, is a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner. Green buildings are designed to meet certain objectives such as protecting occupant health; improving employee productivity; using energy, water, and other resources more efficiently; and reducing the overall impact to the environment.

Principles Green Economy

Here are ten interrelated principles that cover key dimensions of a green economy:

- **The Primacy of Use-Value, Intrinsic Value & Quality:** This is the fundamental principle of the green economy as a service economy, focused on end-use, or human and environment needs. Matter is a means to the end of satisfying real need, and can be radically conserved. Money similarly must be returned to a status as a means to facilitate regenerative exchanges, rather than an end in itself. When this is done in even a significant portion of the economy, it can undercut the totalitarian power of money in the entire economy.
- **Following Natural Flows:** The economy moves like a proverbial sailboat in the wind of natural processes by flowing not only with solar, renewable and "megawatt" energy, but also with natural hydrological cycles, with regional vegetation and food webs, and with local materials. As society becomes more ecological, political and economic boundaries tend to coincide with ecosystem boundaries. That is, it becomes bioregional.
- **Waste Equals Food:** In nature there is no waste, as every process output is an input for some other process. This principle implies not only a high degree of organizational complementarity, but also that outputs and by-products are nutritious and non-toxic enough to be food for something.
- **Elegance and Multifunctionality:** Complex food webs are implied by the previous principle--integrated relationships which are antithetical to industrial society's segmentation and fragmentation. What Roberts & Brandum (1995) call "economics with peripheral vision", this elegance features "problem-solving strategies that develop multiple wins and positive side-effects from any one set of actions".
- **Appropriate Scale / Linked Scale:** This does not simply mean "small is beautiful", but that every regenerative activity has its most appropriate scale of operation. Even the smallest activities have larger impacts, however, and truly ecological activity "integrates design across multiple scales", reflecting influence of larger on smaller and smaller on larger (Van der Ryn and Cowan, 1996).
- **Diversity:** In a world of constant flux, health and stability seem to depend on diversity. This applies to all levels (diversity of species, of ecosystems, of regions), and to social as well as ecological organization.

- **Self-Reliance, Self-Organization, Self-Design:** Complex systems necessarily rely on "nested hierarchies" of intelligence which coordinate among themselves in a kind of resonant dance. These hierarchies are built from the bottom up, and--in contrast to civilization's social hierarchies--the base levels are the most important. In an economy which moves with ecosystem processes, tremendous scope for local response, design and adaptation must be provided--although these local and regional domains must be attuned to larger processes. Self-reliance is not self-sufficiency, but facilitates a more flexible and holistic interdependence.
- **Participation & Direct Democracy:** To enable flexibility and resilience, ecological economic design features a high "eyes to acres" ratio (Vander Ryn & Cowan, 1996)--that is, lots of local observation and participation. Conversely, ecological organization and new information/communications technologies can provide the means for deeper levels of participation in the decisions that count in society.
- **Human Creativity and Development:** Displacing resources from production and tuning into the spontaneous productivity of nature requires tremendous creativity. It requires all-round human development that entails great qualities of nurture. These are qualities of giving and real service that have been suppressed (especially in men) by the social and psychological conditioning of the industrial order. In green change, the personal and political, the social and ecological, go hand-in-hand. Social, aesthetic and spiritual capacities become central to attaining economic efficiency, and become important goals in themselves.
- **The Strategic Role of the Built-environment, the Landscape & Spatial Design:** As Permaculturalist Bill Mollison has emphasized, the greatest efficiency gains can often be achieved by a simple spatial rearrangement of system components. Elegant, mixed-use integrated design which moves with nature is place-based. In addition, our buildings, in one way or another, absorb around 40 per cent of materials and energy throughput in North America. Thus, conservation and efficiency improvements in this sector impact tremendously on the entire economy.

What are the Economic Benefits of Green Buildings?

A green building may cost more up front, but saves through lower operating costs over the life of the building. The green building approach applies a project life cycle cost analysis for determining the appropriate up-front expenditure. This analytical method calculates costs over the useful life of the asset. These and other cost savings can only be fully realized when they are incorporated at the project's conceptual design phase with the assistance of an integrated team of professionals. The integrated systems approach ensures that the building is designed as one system rather than a collection of stand-alone systems. Some benefits, such as improving occupant health, comfort, productivity, reducing pollution and landfill waste are not easily quantified. Consequently, they are not adequately considered in cost analysis. For this reason, consider setting aside a small portion of the building budget to cover differential costs associated with less tangible green building benefits or to cover the cost of researching and analyzing green building options. Even with a tight budget, many green building measures can be incorporated with minimal or zero increased up-front costs and they can yield enormous savings (Environmental Building News, 1999).

LEED GREEN BUILDING RATING SYSTEM

Introduction

There have been buildings, which adopt one or more ‘Green’ features. To recognize the extent of green features

that a building adopts, rating systems have been evolved and come of age in the U.S. and Europe. These rating systems are playing a pivotal role in market transformation of the Green Building Industry. The prime objective of these rating systems is to bring in a change in the market where in the user demands green products. One of the popular rating systems being adopted in the U.S. is the LEED system of the US Green Building Council based at Washington. Canada, China, India and Spain already have building projects, which have registered for the LEED rating. Australia, France, Hong Kong and Japan have been evincing keen interest in adopting the LEED rating system.

What is LEED?

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System was created by the U.S. Green Building Council (USGBC) to establish a "common standard of measurement" for "green" buildings. LEED attempts to define a term that is often considered indefinable-sustainability. USGBC members determine those elements that contribute to the sustainability of a building and promote LEED products and resources as a path to meet sustainable building-goals. Established in 1993, membership in USGBC has grown tremendously following the release of its LEED pilot in 1999-from around 300 members in 2000 to almost 4,000 members in the first quarter of 2004.

The LEED Green building rating system is a voluntary, consensus-based national standard for developing high performance, sustainable building. Members of the USGBC representing all segments of the building industry developed LEED over a seven-year period and continue to contribute to its evolution. Although the founders and developers saw this standard as appropriate for the United States commercial building market, LEED has applied to the buildings of all types throughout the world.

LEED Standards

Table 2: LEED Rating Systems

Type	Description
LEED-NC	LEED for New Construction
LEED-EB	LEED for Existing Buildings
LEED-CI	LEED for Commercial Buildings
LEED-CS	LEED for Core and Shell*
LEED-Homes	LEED for Homes*
LEED-ND	LEED for Neighborhood Development*

Levels of Rating

The following are the different levels of LEED-EB rating awarded to projects. Total number of available points is 85 with 6 prerequisites.

Table 3: Different Levels of LEED-EB Rating

Level	Earned Points
Certified	32-39 points
Silver	40-47 points
Gold	48-63 points
Platinum	63-85 points

Green Buildings in India

LEED Rated Buildings in India

The LEED – India rating system is being adopted all over the country. There are various LEED accredited

professionals in the country. The table below shows the LEED rated buildings in the country.

Table 4: LEED Rated Buildings in India

Sr. No.	Building Name	Location	Square Footage	Building Usage	Rating Awarded
1	CII-Sohrabji Godrej Green Business Centre	Hyderabad	20,000	Office	Platinum
2	ITC Green Centre	Gurgaon	1,70,000	Corporate office	Platinum
3	Grundfos Pumps India Pvt Limited	Chennai	32,000	Corporate office	Gold
4	Wipro Technologies	Gurgaon	1,75,000	Office for software development	Platinum
5	NEG Micon India Pvt Limited	Chennai	18,000	Corporate office	Gold

Upcoming Green Buildings in India

Table 5: Upcoming Green Buildings in India

Sr. No.	Building Name	Location	Square Footage	Building Usage
1	North Delhi Power Ltd	New Delhi	54,000	Corporate Office
2	Indian Machine tools Manufacturers Association -	Bangalore	4,00,000	Exhibition & Convention Centre
3	CII -Naoroji centre of Excellence	Mumbai	1,00,000	Office
4	K Raheja Corporation	Mumbai	1,20,000	Office
5	Technopolis	Kolkatta	6,50,000	IT Park
6	Olympia Technology Park	Chennai	12,00,000	IT Park
7	IGP office	Gulbarga	28,000	Office
8	ONGC	New Delhi	5,05,000	Corporate office
9	ONGC	Mumbai	1,56,000	Corporate office
10	ONGC	Dehradun	2,10,000	Corporate office

Green Building Movement in India

The Green Building movement has gained tremendous momentum during the past 3-4 years, ever since the CII – Sohrabji Godrej Green Business Centre embarked on achieving the prestigious LEED rating for their own centre at Hyderabad. The 'Platinum Rating' for the CII – Sohrabji Godrej Green Business Centre building has sensitized the stakeholders of the construction industry. Today, several Corporates and Governments are considering Green Buildings in a major way. This has resulted in a spurt in the demand for green materials and equipment. The Indian materials and manufacturers are now faced with the challenge to seriously look at green features to meet the growing demand for Green Buildings.

Green Building Potential in INDIA

There is a tremendous potential for construction of Green Buildings in India. The overall investment towards urban building construction in India is estimated to be Rs.45000 million annually. This could open up a plethora of opportunities for several stake holders like construction industry, architects, material, equipment manufacturers etc in India and abroad.

The projected growth potential for Green Buildings in India is shown in the following table:

Table 6: Growth Potential for Green Buildings in India

Year	Projected Certified Buildings (No's /Year)	Estimated Market Potential (Mn)
2005	10	1,800
2006	20	3,600
2007	30	5,400
2008	45	8,100
2009	70	12,600
2010	100	18,000

Performance and Benefits of Green Buildings

- Green Buildings are designed for cost effectiveness and resource conservation.
- If there is an increase in the first costs for Green Construction, it is easily recoverable in a short period of time.
- Green buildings boost the employee productivity – the number one asset for most businesses.
- Green Buildings enhance occupant health, safety, and well-being.
- Clean and healthy buildings can reduce legal claims and liabilities for the owners.
- High performance features translate into high value of tenants.
- Property values increase for developers and owners from leasing through operations and maintenance.
- Public and private incentives support better buildings.
- Green Buildings generate good will and publicity in the community.
- Communities are a major beneficiary Green Buildings as they require less drain on local infrastructure, contribute to local economic development by focusing on local purchasing, and attract tourists.

Day Lighting Design

Building occupants place a premium on natural light and a view to the exterior. If carefully admitted and controlled, daylight enhances the visual quality of interior spaces, and offers many psychological benefits that are difficult and expensive to replicate with electrical lighting. Natural light has inherent variability and unique spectral qualities that reveal and highlight interiors. Providing naturally lit interiors has been shown to increase occupant satisfaction, lower absenteeism, and improve worker productivity and retail sales.

Day lighting design has a major impact on the form and orientation of buildings. First, the building and its openings — windows, skylights and roof monitors — must be oriented to allow light to enter interior spaces, without causing glare or visual discomfort. As well, design for day lighting can constrain the depth of buildings, to allow natural light in most occupied spaces. This limitation can be greatly eased by the use of light distribution strategies, such as light shelves and ceiling slopes, that extend the depth of daylight space.

Figure 2: Orientation of Building for Day lighting

Design for Solar Heating

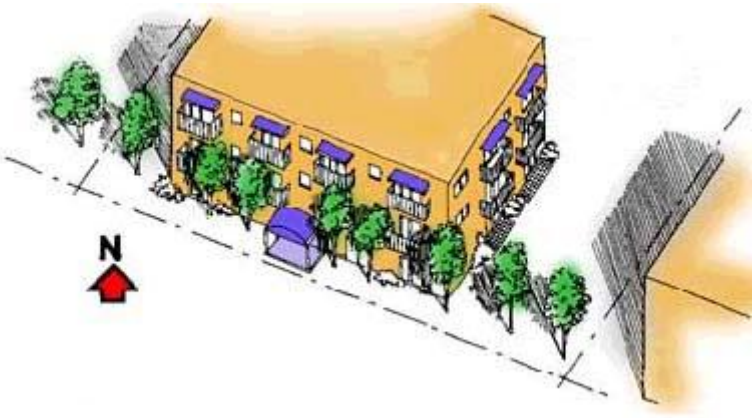

Figure 3: Orientation of Building for Solar Heating

Although reducing cooling and electric lighting use are major concerns in CII-Green Building, passive solar heating can be an effective strategy in the buildings, especially residential, hotels and others with low internal cooling loads. The high percentage of clear skies during winter allows the use of sunlight to reduce or even eliminate the need for supplemental heating. Direct gain through south-facing windows, clerestory windows and roof monitors is the most common method of passive solar heating. These should have access to direct sunlight between 10 am and 2 pm from November to March and should be equipped with control devices to avoid overheating at other times. A glass with thickness of 9inch is provided for sloping roof, the gap between two glasses is 5mm to 6mm is filled with organ gas for avoiding incoming of solar intensity, due to which inside air remains cool.

Where Site Conditions Permit

- Locate the building toward the north and east parts of the site for greatest wall and roof exposure.
- Orient the building with the long side east-west for highest winter gains and lowest summer gains. Southeast or southwest orientation can capitalize on morning or afternoon solar gains respectively without major losses in performance. Carefully analyze the building program to identify spaces and activities that benefit from passive solar heating. Locate spaces that require heating where they have direct access to winter sun and spaces that require cooling to face north or east. Use a sun path diagram and shading masks, or simulation to assess potential shading on roof areas and vertical southeast, south and southwest facing surfaces.

Cautions

- Constrained urban sites make it more difficult to optimally locate buildings, and require greater care in building envelope design.
- Locating building at the northern edge of the site may require shaping/stepping the building to minimize shading of neighboring properties.
- Building form and orientation only establish the potential exposure to the sun. The area and location of windows must also be carefully planned.

Design of Wind Tower

Wind tower is constructed at a height of 50 ft. because of natural air is flowing at the height of 50 ft. At the top of wind tower a sprinkler system is provided for cooling of interior air in the building, this wind tower is directly connected to main building through foundation. Generally this wind tower is used when inside & outside humidity is more.

Figure 4: Wind Tower

- Fresh air intake through towers
- Thermal mass
- water spray
- Drop in air temperature 5 – 7oC
- Results in 7 – 10% reduction of air conditioning load

Sustainable Site

Roof Garden

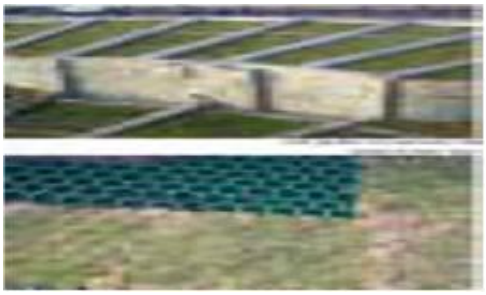

Figure 5

- To reduce heat ingress into the building.
- 2 inch deep plastic trays filled with earth.
- Conventional terrace garden 6-12 inch deep soil
- Load on the structure reduced tremendously

Waterless Urinals

Figure 6

- Cartridge with sealing liquid
- Blue liquid
  - 95% biodegradable
  - Acts as a seal
  - Density lower than urine
  - Cuts of smell

Figure 7

Root Zone Treatment

- Wastewater treatment system
- Root Zone Treatment:
  - Biological Mechanis
  - Treated water used for irrigation

Energy Efficiency

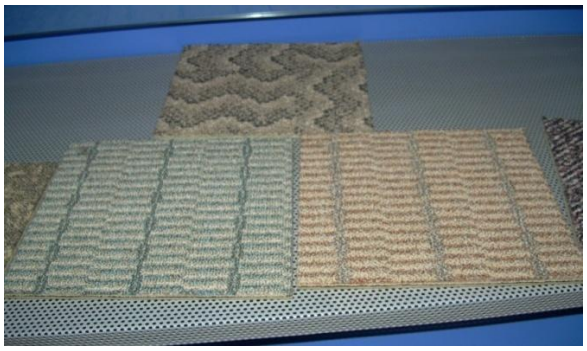

Figure 8

Overall Reduction

- 55% on total energy vis-à-vis ASHRAE
- 40 % on Air-conditioning load
- 88% on lighting energy

Low VOC Carpet

- CRI Certified
  - Total VOC is less than0.50 mg/sq.m-hr
- Carpet Adhesives total
  - VOC less than 10 mg/sq.mt-hr

CONCLUSIONS

- 50% reduction in overall energy
  - Day lighting, Energy efficient CFLs, Day light Sensors, etc
- 90% Reduction in water use
- Optimizes energy efficiency and conserve natural resources.
- Generates less waste and provides healthier space for occupants ,as compared to conventional building

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